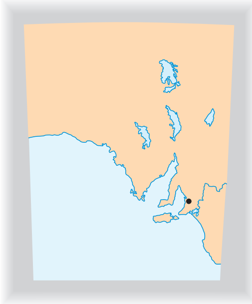
TECHNICAL REPORT RELEASE

Soils, Stratigraphy and Engineering Geology of the near surface materials of the Adelaide Plains



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Introduction

Problem soils in the vicinity of Adelaide were first recognised by early white settlers who referred to them as undulating 'Bay of Biscay' soils, a reminder of their rough sea passage to South Australia. It was agriculturalists who initially sought solutions to problem soils in which soil structure, fertility and poor drainage affected crop yield. In the 1920s these problems were investigated by the Council for Scientific and Industrial Research (CSIR, now CSIRO), which established a Division of Soils at Urrbrae in suburban Adelaide. Post World War II urban expansion led to the use of previously undesirable soil types for development and a consequent increase in the failure of masonry buildings due to soil subsidence and heave. These difficult foundation conditions soon came to the attention of civil engineers, who then wanted to know the extent and properties of these 'problem soils'.

Severe cracking in a domestic house internal wall in the Athelstone Park area caused by differential heave of a black earth soil and the underlying Keswick Clay. (Photo 42051)

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The South Australia Department of Mines (SADM) became involved in the late 1940s and joined with CSIRO Division of Soils to map soils around metropolitan Adelaide and to test these for civil engineering purposes. The publication of SADM Bulletin 32, *The soils and geology of Adelaide and suburbs* (Aitchison *et al*., 1954), resulted from this first joint investigation. The bulletin contained a 1:144 830 soil map and six colour plates depicting 12 typical soil profiles. A classification was presented (based on the World Great Soil Groups) containing 29 soil types assigned to 18 soil associations, with described profiles ranging in depth from one to two metres. This system is unique to Adelaide.

More than a decade later, four coloured soil maps at a scale of 1:15 840, with explanatory booklets, were issued by SADM as the 'Metropolitan Soil Map Series' (Steel and Taylor, 1968; Taylor, 1969, 1970a,b). The maps covered the Adelaide Upper Plains and Hills Face Zone, areas where most urban expansion was then occurring and considered to contain the most problem prone soils from a geomechanical perspective.

A black cracking clay soil overlying the Keswick Clay (both extremely reactive materials) exposed in an excavation at Modbury. (Photo 43664)

The second major publication on the civil engineering properties of Adelaide soils was SADM Bulletin 46, The soils and geology of the Adelaide area (Taylor et al., 1974). Included were 12 colour plates of soil profiles and a coloured soil map at a scale of 1:50 000 (Taylor, 1972). Bulletin 46 refined the soil classification system of Aitchison et al. (1954) by using data from over 5 000 soil investigations carried out by both private consultants and public utilities. Additional information was gained by field mapping and site examinations, but soil profile descriptions were restricted to the upper 1–2 m and only cursory examination and description of underlying materials was attempted.

Investigations during the 1960s by the SA Housing Trust and CSIRO indicated that clay layers underlying the surface soils were causing long and short-term cracking of buildings and their foundations through settlement and heave. By the 1970s, consultant civil engineers and engineering geologists in Adelaide were drawing similar conclusions about these deeper clay layers.

A detailed review and compilation of the Adelaide City soil, near-surface geology and geotechnical problems was presented in Bulletin 51, *Engineering geology of the Adelaide City area* (Selby and Lindsay, 1982). However, the suburban areas were not included and remained poorly documented in a publicly available form.

Difficulties with the field application of the Aitchison–Taylor system of soil types, their depth limit of 2 m, and problems with the reactivity of subsoil clays, led consulting engineers in 1979 to formally call for a new investigation into Adelaide's soils and geology and their geomechanical properties.

Metro-Adelaide soil and geology investigations

Accordingly, CSIRO Division of Soils and MESA commenced a joint investigation of Adelaide problem soils and near-surface geology. MESA provided a geologist, drilling hardware and personnel, permanent core storage and some test facilities, while CSIRO provided a pedologist–geomorphologist, laboratory test equipment and staff, and routine analytical services. The objectives of the investigation were to:

- re-examine the soil systems of Aitchison *et al.* (1954) and Taylor *et al.* (1974)
- delineate subsoil clays, sediments and rock units to depths of 10 m where possible
- establish a series of cored holes (benchmark sites) over the metropolitan area and to permanently retain the core for reference
- log each cored hole using established pedological, geological and geomechanical procedures
- sample and test representative units from these cores
- present results in the form of an integrated field guide, laboratory reference and office planning tool.

Fieldwork commenced in 1980 with drilling, core logging, sampling and laboratory testing, proceeding by annual stages. Each stage involved 15–50 drillholes along a series of transects across the Adelaide Plains, aligned with the natural slope of the land (Fig. 1). The location and density of drillsites were determined by considering access, the geological variability of soil and subsoil materials, and depth of bedrock. Drilling was undertaken with a truck-mounted Gemco rig and core recovery was by means of wireline retrieval of split core barrels through hollow flight augers. A network of 154 cored drillholes was established, with an additional 16 cored holes from two related MESA drilling projects so as to obtain a more complete coverage of the metropolitan area. Cores from one of these ('The Land Level Change Project'; holes 158 to 169) provide an indication of soil and sediment variability over short distances due to the clustering of drillholes. From the 170 drillholes, 1 510 m of core were obtained and are now permanently housed for future reference in the MESA Core Library at Glenside. Approximately 1 200 samples were tested for physical and mineral–chemical characteristics at an average of six tests per sample. Logging, sampling and testing proceeded in parallel with the drilling programs and in total took seven years. Data analysis and synthesis was carried out over the following five years.

Results

The Aitchison–Taylor soil classification system has been retained as a broad reference framework and to permit correlation with other work. However, to more precisely specify soil conditions at individual sites the *Factual Key* soil classification of Northcote (1979) has also been adopted, leading to 61 Principal Profile Forms being identified during this investigation.

A revised near-surface geology has emerged, including 30 geological units, the formal recognition and revision of one previously informally named unit (Keswick Clay), and a revision of the Fulham Sand and upper part of the Hindmarsh Clay. A new unit named Kilburn Sand was recognised and defined. Eight units with informal 'names of convenience' have been introduced to facilitate a more complete stratigraphic framework. The new and redefined units are described in more detail in other publications (cited within the text) while the informal units await recognition. A revised edition of the out-of-print *Soil map of Adelaide* (Taylor, 1972) was released; the revisions were made by the present authors and include on the map reverse a set of 'Cautionary Notes' advising on map use and limitations (Taylor *et al*., 1989).

Geomechanical testing used both long-established standard methods as well as newer tests, with more precisely controlled end-points than were in common use. The results have yielded some surprisingly uniform trends and consistent relationships, given the heterogeneity of the soils and sediments of the Adelaide Plains (Fig. 2).

Samples from the cores have undergone geomechanical and soil tests, including: Atterberg limits, particle size analysis, solute electrical conductivity and a new swell-shrink test (SST). This new test has yielded: strains (vertical, horizontal, volume), water contents at fixed suction end-points (pF3.0 and sorption limit pF6.34) and wet bulk density. A series of derived parameters from the SST are also presented and include: water content and suction at the shrinkage limit, and an instability index (Ip''_{t} — based on total suction). A number of reactive soils and clays were examined using powder X-ray diffraction techniques to determine their mineralogy.

Testing has demonstrated that the majority of Adelaide's reactive soils are composed of clays with a high affinity for water (i.e. smectites, illites, and intimate mixtures of these). Black earth soils are only half as reactive as the substrate Keswick Clay. The instability index Ip''_{t} is a useful indicator for evaluating the potential reactivity of a site and some rapid methods are presented for obtaining this from conventional testing. Its judicial use is recommended though, as this index is strongly influenced by clay solute salinity, such that high salinity may yield an anomalously high Ip''_{t}. A limited statistical analysis of the data is provided for each test parameter.

Presentation

Results of the investigation are presented in tabular and graphical forms with discussion and analysis in eight chapters and three appendices. Direct observations and measurements from each cored hole are presented on multi-disciplinary 'Composite Log' sheets that display groundwater intersections, textural, pedological, geological, and engineering descriptions as parallel logs, together with sample test results (Fig. 3). A split (magnified) scale has been applied to the graphic log first metre, allowing upper soil characteristics to be visually presented, from which soil classifications are derived. Test result derived values and indices are tabulated separately in Appendix 1. Soil and geological units are individually described then placed into context within the main geomorphic zones of the study area. Key geomechanical features are indicated for each unit and for each geomorphic zone. The test methods and results are set out in Appendices 1 to 3 and include examples of alternative test procedures where appropriate. Discussion and analysis of the geomechanical testing is in Chapter 5. Important geomechanical implications arising from the investigations are contained in Chapters 2 to 7; these include, soil defects, gilgai, tree effects, anthropogenic excavations, site management and environment. Earthquake hazard is highlighted in Chapter 8. Maps of soil, sediment and rock distribution patterns have been restricted to specific units or groups of units to minimise problems of presenting multivariate spatial data in only two dimensions. In addition, buildings, cut and fill earthworks, landscaping and the various ground covers associated with urban development precluded detailed field mapping. Instead of a complex map, the 3D geologic structure of the Adelaide Plains has been represented by two sets of cross-sections, one set aligned approximately parallel to, and the other set normal to, the contours.

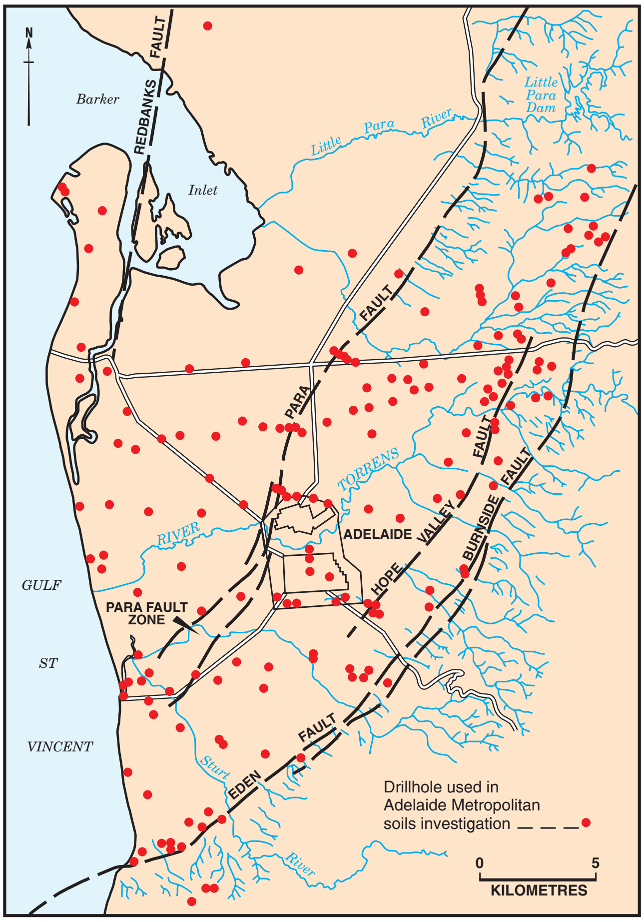

Fig. 1 *Drillhole locations for the 170 cored sites across Adelaide.*

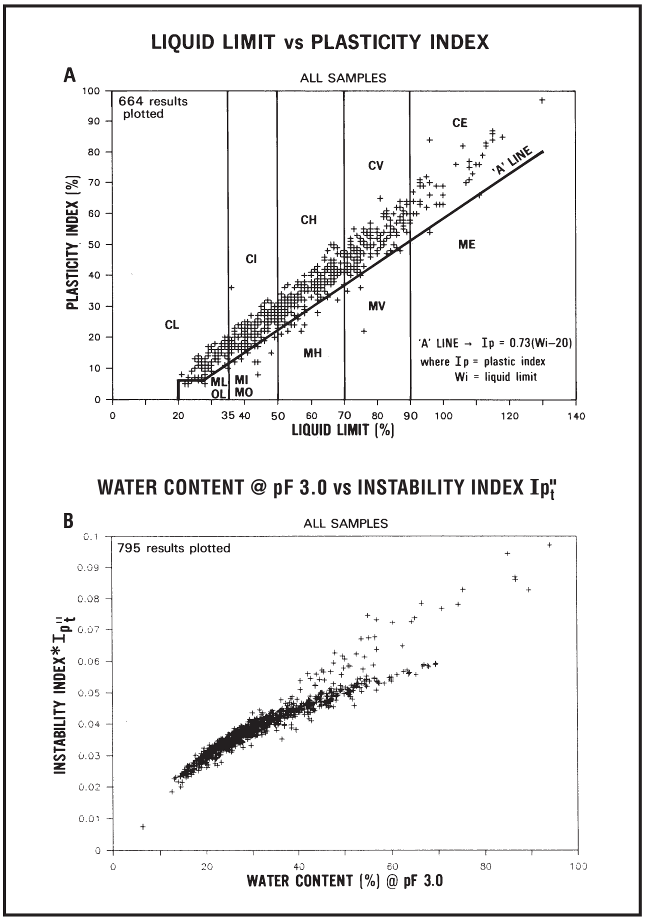

Fig. 2 *Geotechnical test data: (A) displays the range of conventional Atterberg limit results, (B) displays data from the newer swell–shrink test.*

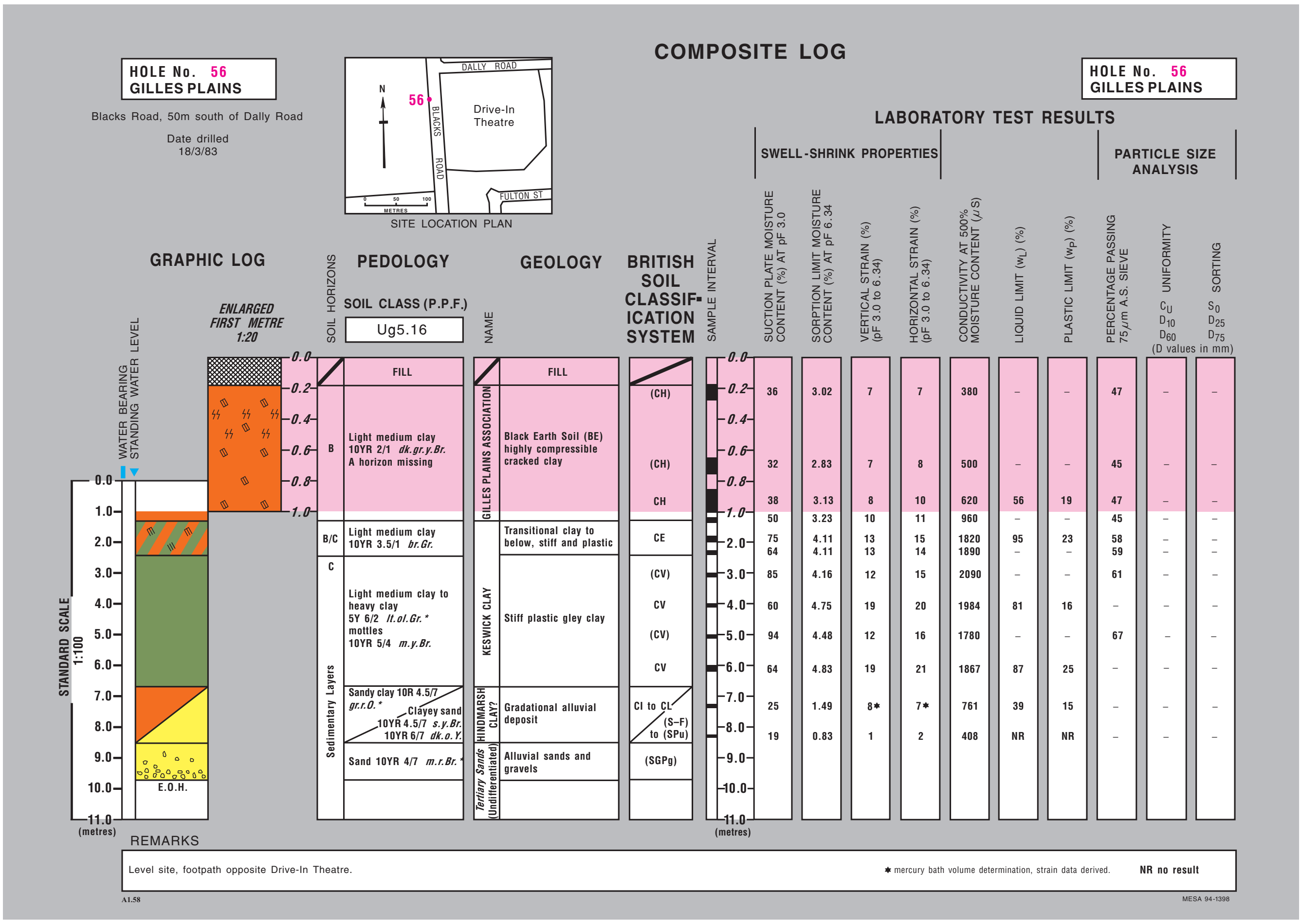

Fig. 3 *An example of the Composite Log sheets (reduced from the original A3 size) for hole 56, the most reactive site tested in the investigation.*

Applications and potential users

This publication, released as MESA Report Book 94/9, is presented as a three volume set: Vol. 1 — text and tables in A4 format, Vol. 2 — plans, figures and plates (A3 colour), and Vol. 3 — appendix figures including logs (A3 colour). It provides a tool for pre- and post-development planning, design and management, and offers a cost-effective information source for those sites with existing buildings exhibiting structural failure requiring remediation or a modified approach for new additions.

Potential user groups include: civil engineers, geomechanicists, engineering geologists, geotechnicians, architects, town and city planners, builders, urban footing designers, local and State Government agencies, road designers, landscape architects, underground service providers and/or repairers, urban land developers, pre-sale property inspectors, professional home renovators, urban horticultural consultants, urban environmental consultants and archaeologists.

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